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Stability of Tuber Shape in *Dioscorea rotundata* Variants

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ABSTRACT- The shape of yam tubers is highly variable within and between varieties. Both genetic and environmental factors, such as soil structure play a significant role in determining tuber shape. This variable nature of yam tubers makes the development of machines for tuber harvesting difficult. For effective mechanisation of yam harvesting, selection of cultivars with good tuber shape needs to be made. As a preliminary investigation, the variability of the diameter to length ratios in three variants of the white yam was studied. The three varieties of the *Dioscorea rotundata* (Amola, Ekpe and Obiaoturugo), exhibited varying tuber shapes both within and between varieties. The tuber shape repeatability coefficients for the varieties were found to be 96% for “Amola”, 50% for “Ekpe” and 13.4% for “Obiaoturugo”. A tuber shape in the white yam is genetic and thus can be maintained from year to year and across locations. It is therefore, possible to transfer the genes for shape between varieties. The development of yam varieties with appropriate tuber shapes, which can be harvested mechanically is possible.

Key-words: *Dioscorea rotundata*, Tuber shape, Variability and Stability, White Yam

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INTRODUCTION

The root and tuber crops are important food crops in the Sub-Saharan Africa as they are staple crops. These crops, more especially, the yams are critical in the food economies in these countries [1,2]. They are widely cultivated and form very important starchy food for many people in this region.

In the world scale, Nigeria and Ghana grow and produce most of the global yams accounting for about 75% of the world production [3]. However, yields in these countries especially, Nigeria has been declining steadily. The pattern shows that the yield of the yams in Nigeria, in the 1980s, which stood at about 12 Mt/ha dropped to about 8 Mt/ha by 2004. This trend has been variously attributed to the use of shorter fallow periods, the frequent use of unproductive old land races and the use of marginal lands due to pressure for land for urbanisation, for yam cultivation.

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Yams are relatively, more expensive to cultivate than the other root and tuber crops. They invariably require staking for high yields, and cultural practices in its cultivation require heavy labour inputs (from land preparation to harvesting). For yam production to advance, its cultivation must be based on large scale production, which will require massive mechanisation of most of the farm operations. One of these essential farm practices is tuber harvesting.

Onwueme [4] recognised for effective mechanisation of yam harvesting, selection of cultivars with good tuber shape need to be made. Yams for effective mechanized harvesting should not suffer breakages during harvesting. Also, they should not be branched and the yam stands should bear shallow lying tubers. Variants already known to possess some of these traits such as Akali, Okwocha and Ehukwu exist.

A programme for the development of yams with round tuber shapes which would be more amenable to mechanised harvesting should indicate the repeatability of the tuber shape chosen. The selection of parents with the desired tuber shape and the improvement of other variants for tuber shape can then be followed up.

A mechanised yam harvesting proposition should be based on the assumptions that the diameter of the tuber should be less than the within row spacing and that the lengths of the yam tuber should be less than or equal to the diameter. A close within row spacing of 25 cm is applicable to commercial rounder or oval shaped yam with D/L ratio approximately 0.5 with L about 15 cm and D about 7-8 cm (where D is the diameter of the tuber and L is its length) is hypothetically ideal for mechanised harvesting in view of the typical harvester already developed for a crop like sugar beet.

The shape of yam tubers is highly variable within and between varieties [5,6]. Both genetic and environmental factors, such as soil structure play significant role in determining tuber shape. In some cultivars, the tubers grow to a great depth in the soil and may be of great length, while in some the tubers are shorter, rounder and are produced in the shallower layers of the soil [7]. This variable nature of yam tubers as mentioned earlier make the development of machines for tuber harvesting difficult. Damages due to breakage and bruises during harvesting using traditional implements like wooden diggers in farmer's fields are high, thus reducing the economic yield of the crop.

As a preliminary investigation towards achieving these long term objectives, this paper attempts to study the variability of the diameter to length ratios in three variants of the white yam.

MATERIALS AND METHODS

This trial was conducted during the 2014 cropping season and repeated in 2015, in the research farm of National Root Crops Research Institute, Umudike, Umuahia, Abia State, Nigeria.

Tubers of three local cultivars of the white yam (*Dioscorea rotundata*),"Amola", "Ekpe", and "Obiaoturugo", were sorted out into three shape groups: rotund, medium and narrow shapes. The tuber shape indices of tubers in the three groups were determined by dividing the diameter (D) with the length (L) of the tuber, thus Tuber Shape Index (TSI) = D/L [8].

The experimental design was a randomised complete block design, replicated four times with treatment combinations of the three cultivars ("Amola", "Ekpe" and "Obiaoturugo") and groups of their tuber shapes (rotund, medium and narrow) as treatments.

Uniform tuber propagules, each weighing about 350g of the cultivars in the various treatment combinations were planted whole on 1mx1m ridges. The plants were staked in the traditional method with Indian bamboo stakes. Cultural practices included weeding (maximum of four weedings). Fertilizer mixture dressing of 6:7:14 NPK at the rate of 300 kg/ha plus 100 kg/ha of magnesium sulphate ($MgSO_4$) was applied by ringing ten weeks after planting.

Tubers were harvested at maturity and their tuber shape indices estimated according to the method described earlier. Determination of repeatability of tuber shapes was by the intra-class correlation method of Falconer [9] using repeated measurements of 10 samples from each tuber shape group across the cultivars (before planting and after harvest) giving a total of 30 samples per cultivar. Data collected were subjected to a two way statistical analysis of variance and significant effects were compared according to Obi [10].

RESULTS AND DISCUSSION

The tuber shape as measured by tuber shape index (TSI) showed that the tubers of "Obiaoturugo" and "Amola" were more rotund, having TSI values of 0.44 and 0.37 respectively than the tubers of "Ekpe" with TSI value of 0.22 (Table 1). The shapes of the parent tuber propagules did not differ significantly from the shape of the harvested tubers (Table 2). This was supported by the analysis of variance on repeated measurements on tuber propagules planted and tubers harvested (Table 3, Table 4).

Table 1: The tuber shape indices (TSI) of the parent yam cultivars

Cultivar	Tuber shape group	Tuber shape index group	*Normal general tuber shape index
Obiaoturugo	Rotund	0.6 – 1.0	0.47
	Medium	0.3 – 0.5	
	Narrow	0.1 – 0.2	
Amola	Rotund	0.6 – 1.0	0.50
	Medium	0.3 – 0.5	
	Narrow	0.1 – 0.2	
Ekpe	Rotund	0.4 – 0.6	0.3
	Medium	0.3 – 0.4	
	Narrow	0.1 – 0.2	

***The normal general tuber shape index was estimated by sampling 100 tubers from each cultivar**

Table 2: The effect of shape of parent tuber propagule on the tuber shape index of harvested tubers

Cultivar	Harvested Tuber			Mean
	Rotund	Medium	Narrow	
Obiaoturugo	0.43	0.48	0.41	0.44
Amola	0.38	0.38	0.36	0.37
Ekpe	0.24	0.22	0.21	0.22
mean	0.35	0.36	0.33	

LSd 0.1 for comparing cultivar means = 0.131
Parent tuber propagule shape means are not statistically different

Table 3: The analysis of variance table for ‘‘Obiaoturugo” TSI

Source	df	SS	MS	Calculated F	F-tab	
					5%	1%
Total	59	1.689434	0.028635			
Between group	29	0.919734	0.03172322	1.23677Ns	1.85	2.39
Within group	30	0.02565				

Ns-Differences are not statistically different

Table 4: The analysis of variance table for ‘‘Amola” TSI

Source	df	SS	MS	Calculated F	F-tab	
					5%	1%
Total	59	o.4713934				
Between group	29	0.1646934	0.005690827			
Within group	30	0.3067	0.010223332	0.555Ns	1.84	2.39

Ns= Differences are not statistically different

The repeatability (t) of tuber shape computed for Obiaoturugo was 13.4% with accuracy of 56.7% and a gain inaccuracy of 43.29%. Computations for Amola were 96%, 37% and 63% for repeatability, accuracy and gain in accuracy respectively, while Ekpe had a repeatability of 50%, accuracy of 25% and gain inaccuracy of 75%.

If repeatability (t) for Obiaoturugo was 13.4%, the stability of shape in Obiaoturugo was low by the criterion applied (D/L index) and with an accuracy of 56.71%, this was indicative of some level of variability in the tuber shape as measured by the tuber shape index (TSI). Visually, the Obiaoturugo tuber is usually cylindrical or nearly club shaped. The gain inaccuracy, which was 43.29%, means that the repeated measurements were necessary and this was shown by such large increase in the gain inaccuracy. It is also shown that more repeated measurements on large number of samples could result in greater accuracy and give more credence to the use of TSI as indicative of shape.

Amola, which had tuber shape repeatability of 96% strongly, suggested a more stable tuber shape based on the TSI values recorded. The low value in accuracy (37%), and high gain (63%), means that repeated sets of measurements were necessary and more sampling could improve the accuracy value.

Ekpe, also with tuber shape repeatability (t) of 50% was also indicative of more stable tuber shape. With a gain in accuracy of 75% and an accuracy as low as 25%, showed that repeated measurements and more sampling could improve the reliability of the use of tuber shape index to describe the shape of its tuber.

The repeatability values of tuber shapes in the yam based on the D/L index as shown by the results was indicated that tuber shapes are cultivar dependent, suggesting a strong genetic influence on the cultivar tuber shapes.

The future potential of yams in West Africa, according to Wilson [11], depended primarily on the success of breeders in developing varieties which can meet the requirements of yam farmers whether large scale or small scale.

If yam production is to remain economically viable and not continue to decline, varieties which have all the conventional attributes of high yield, disease and pest resistance, storage and culinary quality must be bred. However, modernising the yam production, with emphasis on developing varieties suitable for mechanized agriculture is highly needed. This was not meant to imply that there was no room for improving traditional yams which are appropriate for systems of agriculture, where the yam will continue to be treated as a subsistent crop. It is probable that for a long time to come, small-scale, labour intensive farming systems will exist side by side with modern production, particularly in forest regions where large-scale mechanization is often not practicable. This means that more breeding efforts must be aimed at developing improved varieties for these systems. In fact, many of the breeding goals mentioned for modern yam cultivation will be equally beneficial to the small-scale farmer if attributes incorporated into varieties are also tailored to meet his needs.

In the case of yam harvesting, which was generally done in the traditional yam farming systems by hand using spades or diggers, which is a labour-intensive operation that involves standing, bending, squatting, and sometimes sitting on the ground depending on the size of mound, size of tuber or depth of tuber penetration, a labour saving device appropriate for this system must also be considered.

Attempts will be made in the future to collect and screen several white yam variants for oval or near oval shapes and to determine the repeatability of their shapes for the purpose of propagating yams that will be amenable to mechanical harvesting. Efforts will also be made to cross variously shaped yam variants to typed white yams possessing appropriate tuber shapes, in order to recombine and isolate new variables with desired tuber shapes and other good qualities.

CONCLUSIONS

Tuber shapes in the yams are cultivar dependent, suggesting a strong genetic influence. It is therefore possible to breed yams for required tuber shape. This will immensely enhance and boost yam production as it will aid the development of varieties suitable for mechanical harvesting. Replacing most farm operations which hitherto are manually done, with machines will improve the economic potential of yam cultivation in West Africa. Yam harvesting is one of those farm operations manually done.

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